

CHAPTER 3. FLOODING IN KING COUNTY

3.1 THE FLOODPLAIN LANDSCAPE IN KING COUNTY

King County has thousands of miles of river and stream channels with corresponding floodplains. As the word implies, a floodplain is the surrounding flat area that is periodically flooded with water in excess of a river or stream channel's capacity. As such, floodplains are the pressure-release mechanism for rivers and streams to expend excess water and dissipate erosive energy during floods.

3.1.1 Floodplain Processes

Of the myriad of floodplain processes that are critical to a river's structure and ecological function, the most prominent and important is flooding. Flooding triggers recruitment and transport of sediment and woody debris, recharge of shallow aquifers, and channel migration. These processes help to create side channels, swales and other complex valley-floor topographic features, each of which helps to dissipate a river's powerful erosive forces. Other benefits from these floodplain processes include the modification or creation of diverse aquatic and floodplain riparian habitats that sustain productive and diverse native plant, fish and wildlife populations. As floodwaters dissipate, waterborne woody debris and sediment are deposited on the floodplain and in the river channel in the form of gravel and sand bars, affecting the characteristics of the surrounding area of the floodplain.

Biological responses to these physical processes include the establishment of highly productive plant, fish and wildlife communities and the purification of floodwater as it flows through soil and vegetation. Ultimately, biological responses, such as plant community succession and fish and wildlife reproduction, rearing, migration and refuge, are aided by the habitat-forming processes of floods in floodplains. In short, floodplains that are not isolated from their river or stream channels can be among the most dynamic, varied, and productive components of the environment.

3.1.2 Floodplain Characteristics and Development

King County's floodplains reflect a geologic past that includes large-scale tectonic and volcanic processes that occurred over tens of millions of years, a period of extensive glaciation that ended about 15,000 years ago (Booth et al. 2003), and at least one major mudflow, the Osceola Mudflow, which occurred roughly 5,700 years ago. The tectonic and volcanic processes created large-scale landforms, such as the Cascade and Olympic Mountain ranges, the Olympic Peninsula and Puget Sound. The more recent glaciers and mudflows shaped many of the lowland surface features apparent today, including the topography and soils of King County's lowland river valleys. The Osceola Mudflow, which occurred when a flank of Mount Rainier collapsed, released sediment that filled the White River Basin to a depth of 75 feet and eventually settled in the lower Green River valley, converting it from an arm of Puget Sound to the fertile, low-gradient valley that it is today (Booth et al. 2003). These processes and events influenced the length, width, steepness, sediment load and channel forms of King County's large rivers.

Currently, the headwaters and middle reaches of rivers in King County are typically steep and dominated by bedrock and boulders. In these areas, floodplains are often narrow or absent. When these rivers eventually reach the Puget Sound lowlands, however, they flatten out, deposit sediments, and form floodplains that are often broad, ecologically complex and biologically productive.

In the relatively brief time since Euro-American settlement began in the Puget Sound basin, the region's floodplains have been altered extensively by development. Initially these changes were caused by land-clearing and installation of drainage systems that supported land uses such as farming, mining and

railroad transportation. Despite the relatively small population of settlers in the region, major changes occurred at an accelerating pace, including conversion of forested and vegetated floodplains to farmland, removal of woody debris from stream and river channels, channelization and bank armoring, rerouting of major rivers, and the construction of dams for water supply, flood control or hydropower.

These activities changed, often radically, the nature of our rivers. The filling or disconnection of river side channels caused substantial losses of floodwater conveyance and habitat. Bank stabilization, typically using large, angular rock, reduced or eliminated natural riparian structures. Channel roughness was reduced and erosive water velocities increased. Large dams reduced peak flood flows and disrupted the natural flow of sediment and woody debris. Cumulatively, these actions changed many miles of our rivers from hydraulically complex, multiple-thread or braided channels to higher-energy, flume-like, single-thread channels, sometimes in a matter of years. More recently, intensive residential, commercial and industrial land uses have come to occupy the downstream portions of King County's river valleys, exacerbating floodplain management conflicts and costs. It is in these flat, lowland floodplain areas that human development and flooding coincide, posing some of the greatest management challenges in the County.

3.2 COSTS AND IMPACTS OF FLOODING IN KING COUNTY

3.2.1 Types of Flood-Related Hazards

Major flood events along King County's rivers result in two primary types of flood hazards: inundation and channel migration. Inundation is defined as floodwater and debris flowing through an area that is not normally under water. Such events can cause minor to severe damage, depending on the velocity and depth of flows, the duration of the flood event, the quantity of logs and other debris carried by flows, and the amount and type of development and personal property in the floodwater's path.

Channel migration results from erosion, which is the wearing away of a riverbank by flowing water. Ongoing erosion of one riverbank coupled with sediment deposition along the opposite bank results in the lateral movement, or migration, of a channel across its floodplain. A channel can also move by abrupt change in location, called avulsion, which can shift the channel location a large distance in as short a time as one flood event. In regulatory use, "channel migration" refers to both ongoing lateral migration and avulsions. Bank erosion is a component of channel migration.

Channel migration can threaten areas that are not inundated by floods. For example, a home on a high bank, above flood levels, can be undermined by the flood's erosive flows. Damage due to bank erosion can range from minor to severe, depending primarily on whether there is a structure on the affected property. The amount of erosion and channel migration at a site depends on its location on the channel, such as whether it is on the outside or inside bend of a meander, flow velocities, the pattern of debris and sediment accumulation in the channel, and the erodibility of the bank. Some rivers migrate more rapidly than others, such as the Tolt River, and experience sudden and dramatic patterns of bank erosion that can create wholesale changes in the channel's course during a single flood event.

3.2.2 Identifying Areas At Risk from Flooding and Channel Migration

King County identifies areas that are at risk from flooding and channel migration using a variety of mapping, analytic, and property tracking approaches. Flooding due to channel migration has been mapped in four areas of the major King County rivers and tributaries, covering a total of 49 river miles. As of 2005, there are 5,461 acres and 1,106 parcels, out of a total of 623,000 parcels county-wide, located within the mapped channel migration zones (King County 2006). These parcels include 389 structures, with a total assessed value \$179,228,513. Three other river areas, covering about 50 river miles, are currently in the process of being mapped for channel migration zones.

The area at risk from inundation can be characterized by conducting a flood study and preparing a map of the extent of the 100-year floodplain. The 100-year flood is the flood that has a 1 percent chance of occurring in any given year, and the 100-year floodplain is the area that would be inundated by the 100-year flood. Since 1993, King County has made a significant effort to map the extent of the 100-year floodplain along many of the major rivers; but not all rivers have updated maps. As river conditions change, the actual extent of the 100-year floodplain may extend beyond the currently mapped areas. The mapped 100-year floodplains in King County cover more than 25,000 acres, or close to 40 square miles (Table 3-1). As of 2005, there were approximately 2,045 structures in the mapped 100-year floodplains throughout King County, with a total assessed value of \$2.7 billion (Table 3-1). The numbers in Table 3-1 represent floodplains along streams and rivers for which a 100-year floodplain has been mapped in both unincorporated and incorporated areas of King County.

TABLE 3-1.
LAND AND STRUCTURES LOCATED IN MAPPED 100-YEAR FLOODPLAINS IN KING COUNTY

Parcels ^a	Structures ^b	Total Acres in 100-year Floodplain	Assessed Land Value	Assessed Structure Value	Total Assessed Value	Estimated Flood Loss Potential ^c
South Fork Skykomish River						
170	36	1,597	\$1,797,300	\$7,535,600	\$9,332,900	\$2,109,968
Snoqualmie River						
1,880	867	14,614	\$197,372,500	\$258,881,400	\$456,253,900	\$101,730,579
Sammamish River						
710	363	1,598	\$276,328,800	\$485,154,000	\$761,482,800	\$123,419,346
Cedar River						
463	219	2,229	\$102,476,775	\$75,153,425	\$177,633,111	\$20,690,262
Green River						
1,161	496	4,516	\$338,697,100	\$937,851,300	\$1,276,554,573	\$260,721,384
White River						
175	64	617	\$10,287,100	\$14,972,260	\$25,259,360	\$4,165,276
Total For King County Major Rivers						
4,559	2,045	25,171	\$926,959,575	\$1,779,547,985	\$2,707,516,644	\$512,836,815
<p>a. Parcels where at least 50% of the parcel is within the mapped 100-year floodplain.</p> <p>b. The analysis assumes that if 50% or more of the parcel is within the mapped floodplain, the structure or a portion of the structure is likely to be within the mapped floodplain.</p> <p>c. The Estimated Flood Loss Potential is determined using FEMA's flood loss estimation tables. These estimated flood loss values represent the effect of a single 100-year event in today's dollars.</p> <p>d. This methodology does not account for potential flood losses outside of mapped floodplains, such as in the levee protected portions of the Green River valley floor.</p> <p>The data in this table are taken from the King County Flood Risk Assessment contained in Appendix C of this Plan.</p>						

Properties included in FEMA's repetitive loss property inventory are another indicator of floodplain areas that are at risk from flooding. The inventory consists of properties that are insured through the National

Flood Insurance Program and have experienced any of the following since 1978, regardless of changes in ownership during that period:

- Four or more paid flood insurance losses in excess of \$1,000,
- Two paid flood insurance losses in excess of \$1,000 within any rolling 10-year period since 1978, or
- Three or more paid flood insurance losses that equal or exceed the current value of the insured property.

FEMA has instituted several programs that encourage communities to identify and mitigate the causes of their repetitive losses. FEMA requires repetitive loss communities, such as King County, to identify repetitive loss areas, where structures have been subject to repetitive flooding. These areas are identified by the presence of high risk structures that meet FEMA's definition of repetitive loss.

Currently, the FEMA repetitive loss inventory includes 64 properties in unincorporated King County (see Table 3-2). Since 1997, King County has reduced the flood risks associated with 20 of these privately owned properties through the completion of mitigation projects. Seven of these were home elevations, and 13 repetitive loss properties were acquired by King County and their structures demolished. All have been removed from FEMA's repetitive loss property inventory. This Plan provides project level and programmatic recommendations to address the 44 remaining repetitive loss properties. Chapter 5 provides additional detail on proposed repetitive loss property mitigation actions. King County views its total number of repetitive loss properties to be a low estimate of the total number of flood-prone areas, since not all property owners purchase flood insurance through the National Flood Insurance Program.

TABLE 3-2.
2005 REPETITIVE LOSS PROPERTIES ON FEMA'S INVENTORY FOR UNINCORPORATED KING COUNTY, WA

River Basin	Total Number of Repetitive Loss Properties	Repetitive Loss Properties with Completed Flood Mitigation Actions	Repetitive Loss Properties Not Mitigated
South Fork Skykomish	9	0	9
Snoqualmie River	38	19	19
Issaquah River	2	0	2
Cedar River	12	0	12
Green River	1	1	0
Central Puget Sound (Vashon Island)	2	0	2
Total	64	20	44

Source: King County River and Floodplain Management Program, 2005; FEMA National Flood Insurance Program's Community Rating System Repetitive Loss Properties, 2005.

As of 2005, flood insurance policies for repetitive loss properties made up 4 percent of the total number of flood insurance policies in King County. Between 1978 and 2004, claims paid to owners of flood-insured repetitive loss properties accounted for 40 percent of the total damage claims filed by all flood insurance policy holders. This underscores the need for mitigation measures for repetitive loss properties.

3.2.3 Actual Flood Damage and Impacts

The two most serious impacts of flooding along the major rivers in King County are loss of life and property damage. To date, major river flooding in King County has infrequently contributed to injury or loss of life, more typically resulting in property damage. Though property damage is a more common outcome from major river flooding in King County, the potential for injury or death exists, especially in the event of a levee breach or similar unanticipated and rapid change in flooding conditions.

Loss of Life

Flooding on King County's major rivers can generate deep, fast-flowing water and debris over wide areas. Though many people live and work in the vicinity of King County's floodplains, there have been few documented flood-related fatalities. Newspaper accounts indicate that roughly a dozen people have been killed by floods in King County since 1900; most drowned while trying to cross inundated roadways. There is no known record of the number of non-fatal flood-related injuries in King County.

The majority of recorded flood fatalities in King County occurred before 1960, the year that King County initiated its flood warning system. Between 1960 and 1990, King County expanded its flood warning and public education systems. In 1976, two flood-related fatalities occurred on the White River, as a result of rapid and unanticipated flow change on the river (Washington Department of Ecology, 1976). Then, during the 1990-91 flood season, four people drowned in flood-related accidents: a boater during a minor October 1990 flood; a motorist who tried to cross the Woodinville-Duvall Bridge during the Thanksgiving 1990 Flood; a recreational kayaker drowned in the Green River Gorge during the Thanksgiving 1990 Flood; and a motorist whose car was swept off the Tolt Hill Road in a February 1991 flood. Since 1991, there have been no documented flood-related fatalities within King County.

Property Damage

Major flood events in King County have resulted in significant property damage. The total cost, over time, of flood-related damage to private property is not known, since no single public or private entity tracks flood-related private property damage in King County. When a major flood overwhelms local and state resources, and if FEMA determines that effective response is beyond the capability of state and local governments, a governor can request a federal disaster declaration. When a federal disaster declaration is made, federal funding may then be available to repair public infrastructure. It is King County's responsibility to prepare detailed estimates of flood-related damages to publicly owned property. Since 1990, King County has been declared a flood disaster area seven times, with reported flood-related damage to public property totaling over \$21 million (see Tables 3-3 and 3-4). The \$21 million estimate does not include flood damage to private properties or to publicly owned properties that were not eligible for federal disaster assistance.

TABLE 3-3.
FEDERALLY DECLARED FLOOD DISASTERS IN KING COUNTY
(1990 TO 2006): DAMAGE TO PUBLICLY OWNED PROPERTY

Flood Date	Federal Event Number	Damage
January 1990	852	\$5,246,411
November 1990	883	\$3,694,824
December 1990	896	\$477,737
November 1995	1079	\$3,031,519
February 1996	1100	\$4,226,719
December 1996	1159	\$3,576,309
March 1997	1172	\$1,266,446
Total		\$21,519,965

Source: King County Regional Hazard Mitigation Plan, 2003

TABLE 3-4.
FEDERALLY DECLARED FLOOD DISASTERS IN KING COUNTY (1990 TO 2006):
LOCAL, STATE, AND FEDERAL COST SHARE (TO REPAIR DAMAGED PUBLIC PROPERTY)

Flood Date	Event Number	Federal Share	State Share	Local Share	Total
January 1990	852	3,696,349	615,685	615,685	4,927,719
November 1990	883	2,627,506	437,121	437,121	3,501,748
December 1990	896	346,792	57,798	57,798	462,388
November 1995	1079	1,504,057	250,672.50	250,672.50	2,005,402
February 1996	1100	3,476,523	1,013,332.50	145,505.50	4,635,361
December 1996	1159	3,479,123	579,851.50	579,851.50	4,638,826
March 1997	1172	949,834	158,306	158,306	1,266,446
Total		\$16,080,184	\$3,112,766.50	\$2,244,939.50	\$21,437,890

Source: Washington State Department of Emergency Management, 2005.

3.3 FLOODPLAIN MANAGEMENT PRACTICES IN KING COUNTY

Historically, floodplain management consisted of “flood control” measures to protect people, property and infrastructure that focused on localized problems and were implemented in a piecemeal fashion. Over the past century, watershed-wide or reach-level analyses were rarely conducted to investigate the effectiveness or adverse impacts of these site-specific measures. For example, efforts to protect banks along a particular reach in response to localized erosion after a flood often resulted in the transfer of erosion problems during the next flood to adjacent or downstream properties. This would lead to further bank hardening efforts, eventually resulting in the armoring of many miles of riverbank.

In some instances, these projects were marginally successful in controlling erosion and flooding, but they incurred high costs and caused large-scale environmental alteration. Further, they resulted in costly, ongoing channel maintenance and flood damage repair, while fostering a false sense of security among floodplain occupants. In some areas, the solutions were only temporary and flood risks were exacerbated over the long term. Furthermore, most of these flood control efforts did not account for the loss of ecological processes and environmental benefits formerly provided by the natural riverine processes that had been altered.

King County's River Improvement Program was established in 1960 and administered by the Department of Public Works. The program was established after major flooding on the Green and Snoqualmie Rivers in 1959. King County voters approved two bond issues of \$5 million each, in 1960 and 1964, to improve flood control along King County's rivers. These funds, supplemented by the River Improvement Fund, a countywide levy that today generates roughly \$2.5 million per year, supported an aggressive and wide-ranging flood control program throughout the 1960s and 1970s.

The River Improvement Program initially directed its resources toward four types of flood risk reduction activities: construction of levees, revetments, and other flood protection facilities; maintenance of flood protection facilities; flood fighting; and flood warning. The program's flood control strategy sought to confine the floodplain and channel to a narrow corridor. Levees were placed immediately adjacent to riverbanks to contain floods or to "train" the river to go in a certain direction; miles of streambank were kept bare of vegetation and lined with riprap to control erosion and limit the natural migration of river channels. Logjams, gravel bars and deltas were removed at some locations in an attempt to maintain channel capacity and reduce bank erosion problems. During this era of flood control, King County directed significant funds to projects that protected both public and private properties.

The *1993 King County Flood Hazard Reduction Plan* recognized many of the problems associated with traditional approaches to flood control, as practiced during the early days of the River Improvement Program, and new approaches to floodplain management were adopted. The 1993 Plan emphasized buying out and removing structures with frequent flood damage or using bioengineering methods that incorporated riparian vegetation and large woody debris as part of the repair of flood-damaged river facilities. Targeted floodplain land acquisition made it possible to relocate certain levees and revetments landward of their former locations at the top of river banks, thereby providing additional space for flood conveyance, which also supports floodplain restoration, the reactivation of old side-channels and safe accommodation for overbank flooding.

Since 1993, King County has incorporated a broad array of floodplain management strategies, as a function of greater recognition of the high financial and ecological costs associated with a sole dependence upon traditional flood control measures. This recognition has resulted in the implementation of more cost-effective and environmentally beneficial solutions that strive to accommodate, rather than oppose, natural riverine processes. Existing land use conditions and development patterns limit where these ecologically beneficial flood risk reduction solutions can be employed. When sufficient floodplain acreage has been available, implementation of non-traditional flood risk reduction solutions have reduced flood risks, lowered long-term costs of floodplain management, increased aesthetic and recreational values and created a more beneficial environment for fish and wildlife.

King County continues to pursue innovative and comprehensive flood risk reduction strategies in six program areas, as further described in Chapters 4, 5 and 6 of this Plan:

- Maintenance of up-to-date flood hazard information and data sets,
- Management of land uses,
- Maintenance of river channels,

- Management of flood protection infrastructure,
- Provision of flood hazard education and flood preparedness, flood warning, and emergency response, and
- Coordination with public agencies, stakeholder organizations, and private property owners

3.4 KING COUNTY AND THE COMMUNITY RATING SYSTEM

3.4.1 Community Rating System Overview

King County's comprehensive floodplain management program is nationally recognized by FEMA through the Community Rating System, a voluntary incentive program that is part of the National Flood Insurance Program. This program recognizes and encourages community floodplain management activities that exceed the minimum requirements stipulated for participation in the National Flood Insurance Program. Flood insurance premium rates are discounted to reflect the reduced flood risk resulting from community actions meeting the following three goals of the Community Rating System:

- Reduce flood losses
- Facilitate accurate insurance rating
- Promote awareness of flood insurance

For participating communities, flood insurance premium rates are discounted in increments of 5 percent. For example, a Class 1 community would receive a 45 percent premium discount, and a Class 9 community would receive a 5 percent discount. A Class 10 community receives no discount on flood insurance. Credit points are accrued by participating communities under 18 creditable activities organized under the following four categories:

- Public information
- Mapping and regulations
- Flood damage reduction
- Flood preparedness

As of October 1, 2005, 1,018 communities received flood insurance premium discounts under the Community Rating System. Although insurance premium discounts are one benefit of participation in this program, more important benefits result from activities that save lives and reduce property damage. Participating communities represent a significant portion of the nation's flood risk; over 67 percent of the National Flood Insurance Program's policy base is located in these communities. Communities receiving premium discounts through the CRS range from small towns to large metropolitan communities and represent a broad mixture of flood risks, including both coastal and riverine flood risks.

3.4.2 King County Participation

King County began its participation in the Community Rating System in 1990, the federal program's first year of operation. During the early 1990s, FEMA acknowledged King County's progressive approach to floodplain management and profiled King County as a pilot test community to aid in the development of the Community Rating System.

King County received a Class 3 rating in 2005, the highest Community Rating System classification for a county, and the second highest classification overall in the nation. This classification resulted in up to a 35-percent premium reduction within regulated floodplains and 10-percent premium reduction outside of

regulated floodplains for all flood insurance policies in unincorporated King County, effective October 1, 2005. King County's rating amounts to a \$450,536 annual savings to policy holders on the 1,592 flood insurance policies in unincorporated county, or an average savings of \$283 per policy.

King County receives credit for 17 of the 18 possible activities under the Community Rating System. Figure 3-1 provides a breakdown of King County's Community Rating System credit. King County's steadily improving Community Rating System classification since 1990 is a function of the County's commitment to comprehensive and cost-efficient floodplain management strategies. King County's ability to maintain or improve its Community Rating System classification will result from successful implementation of the policy, project, and program recommendations contained within the *2006 King County Flood Hazard Management Plan*.

Figure 3-1

**PERCENTAGE BREAKDOWN OF KING COUNTY'S
COMMUNITY RATING SYSTEM CREDIT**

2006 KING COUNTY FLOOD HAZARD MANAGEMENT PLAN

